MDE Product Development Team
FY13 3rd Quarter Report
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(Compiled and edited by S. Benjamin and B. Johnson)

Executive Summary

Task 1: Improve turbulence guidance from NWP forecasts

- RAPv2 summer 2013 configuration implementation continues to run smoothly on Jet (Boulder, RAP primary cycle) and Zeus (Fairmont WV) supercomputers and initializing experimental HRRR. This configuration includes improved data assimilation for convective storm environment in warm season and winter storms in cold season
- Switchover of NCEP operational production suite, including current operational RAP, to new Weather and Climate Operational Supercomputer System (WCOSS) now scheduled for 23 July (1 week delay)
- 3-month delay for all late 2012 implementations at NCEP. Therefore, RAPv2 implementation at NCEP now scheduled for Q2 FY14 (Jan-Mar).
- RAPv2 now in parallel testing on WCOSS as of early July.
- Three real-time parallel RAP cycles (with extensive verification of each) running on Zeus NOAA research supercomputer located in Fairmont, WV to evaluate further likely enhancements to RAP data assimilation / model system for spring 2014 code freeze.
- NCEP making progress on NAM and NAM-nest

Task 2: Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

- Ongoing evaluation of HRRR forecast skill for convective system and other parameters indicating significant improvements over 2012 with very good overall performance on prediction of convective storms and other small-scale weather phenomena, several reports from NWS forecasters of especially good forecasts for specific events.
- HRRR test code infrastructure successfully installed on NCEP WCOSS computer in anticipation of NCEP implementation in 2014, with recent work by NCEP software engineers yielding a significant speed-up in run-time.
- 3-month delay for all late 2012 implementations at NCEP. Therefore, HRRR implementation at NCEP now scheduled for Q3 FY14 (Apr-Jun).
- Hourly RTMA running again in real-time and progress toward creation of 15-min prepBUFR observation files from GSD NetCDF files, but request additional 2-month delay till Aug. 2013.
- Presentations in early June on HRRR/RAPv2: 1) at NSSL/SPC/OU by Curtis Alexander and 2) at NCEP/EMC by Stan Benjamin. Participation by Curtis Alexander, John Brown, and Eric James at NCEP/Storm Prediction Center Spring Program for experimental forecasting

Task 3: Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

- Upgraded physics configuration now running in both RAPv2 at GSD and in parallel cycle on WCOSS machine at NCEP
- 9-level RUC land-surface model, MYNN PBL, hydrometeor/radiation fix, resulting in improvement in surface wind forecast and 2-m temperature forecast
- Upgraded RUC LSM, Grell-Freitas convection scheme and Olson version of MYNN planetary-boundary and surface layer schemes released as part of official WRFv3.5 code release in April.
- Thompson microphysics scheme used in RAP was successfully ported by NCAR and NCEP to the NMMB under NEMS, setting the stage for more collaboration between NCAR and NCEP on microphysics issues in the future.

- NCAR put on a successful 14th Annual WRF Workshop in late June.

Task 4: Develop convection-ATM-specific improvements to guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA

- Real-time, frozen RAPv2/HRRR system running successfully with gridded field dissemination, real-time web display of graphics and verification of many forecast fields.
- Ongoing monitoring of RAPv2/HRRR system with regards to reliability (including joint reliability with Jet – Zeus failover) and forecast performance.
- HRRR "failover" capability to use feed from Zeus instead of Jet during Jet downtime is working; enhancements necessary to make Zeus completely independent of Jet will come in July.
- Examination of enhanced verification of HRRR convective forecasts, including VIL and echo-top.

Task 1: Improve turbulence guidance from NWP forecasts

Improving turbulence forecast quality involves efforts to improve initial conditions for the RAP and NAM (and HRRR and NAM nests) and to improve the models (WRF-Advanced Research WRF (ARW)-RAP and NOAA Environmental Modeling System (NEMS)- Nonhydrostatic Multi-scale Model – B (NMMB)).

Tasks will include:

- Continuing evaluation of RAPv2 toward early 2014 implementation at NCEP, incorporating changes developed in 2012 and early 2013
- Development of RAPv3 toward 2014 implementation at ESRL and subsequent implementation at NCEP
- Collaborating on developing and testing best approaches for use of hybrid/EnKF/3DVAR data assimilation within common GSI coding structure.

ESRL

Regarding the operational NCEP RAP

The operational RAP at NCEP continues to run without any technical problems, including post processing. The RAP continues to show improved reliability over the previous RUC at NCEP; the March UniPost fix to avoid crashes due to spurious decrease in height with decreasing pressure continues to work flawlessly.

During this quarter, major progress was made toward implementation of RAP on NCEP's new Weather and Climate Operational Supercomputing System (WCOSS). Because WCOSS uses a Linux-based operating system, this transition was made much easier by RAP having been originally developed on such a machine (Jet), with ongoing development occurring on Zeus and Jet. Nevertheless, considerable effort by Ming Hu of GSD working closely with Geoff Manikin of NCEP and some others was required, especially to work out the scripting and I/O details for the partial cycling, to bring this about quickly.

At this writing, both the currently operational RAP and RAPv2 are running on WCOSS in cycling mode. Due to ongoing NCEP preparations for the final switchover from the current NCEP machines, Cirrus and Stratus, to the new WCOSS machines, Gyre and Tide (one of which will be designated the operational machine and the other for NCEP development), the RAPv2 real-time cycle, being on the development side, has suffered frequent interruptions, precluding meaningful evaluation of the RAPv2 cycle there up to this point. Since this code is equivalent to the RAPv2 now running on Jet (Boulder) and Zeus (Fairmont, WV) supercomputers, we think we still have a good evaluation of RAPv2 performance.

The switchover to WCOSS was scheduled for 1200 UTC on Tuesday 16 July. However, we just received notice that due to unresolved controller issues on Gyre, the switchover is delayed one week to Tuesday 23 July. Some not so good recent news from Geoff Manikin is that out of concern for work on lingering unresolved WCOSS issues preempting development work after the switchover to WCOSS, the RAPv2, along with other planned NCEP implementations during FY2014Q1 will be pushed back into FY2014Q2. We also anticipate a further of the implementation of the HRRR at NCEP into Q3 (Apr-Jun) 2014. (See Task 2 for more on HRRR.)

Regarding the ESRL RAP

In our last quarterly report, we described the summer 2013 RAP and HRRR configurations and the path to their completion. A list of the configuration changes in 2013 from the summer 2012 versions of the RAP and HRRR can be found **here**. These form a new baseline for testing of candidate future enhancements in RAP and HRRR, which continued, through FY2013Q3 using the three development RAP cycles on the Zeus computer.

- RAP-dev1, identical to the RAP-primary running on the Jet computer, continues to serve as the backup RAP cycle to support the running of the HRRR on Zeus in an identical configuration to the HRRR on Jet. (See more discussion under Tasks 2 and 4 concerning this strategy for improving the reliability of the HRRR.)
- RAP-dev2 was used during April and early May for continued evaluation of the Grell-Freitas convection parameterization (see Task 3 for more details). During the 15 May through 15 June period RAP-dev2 was temporarily reserved for examining the impact of special dropwindsonde data collected over the western CONUS during the Mesoscale Predictability Experiment (**MPEX**). These data were made available to the RAP-dev2 cycle, but withheld from the RAP-primary.
- RAP-dev3 was used for further testing of how best to use the effective cloud amount field from CLAVR-x early in the quarter and then to examine the impact of bias-correcting temperatures from aircraft observations later.

Related to the late spring in the central CONUS this year, we encountered two snow-related issues in the RAP early in the quarter. One of these was excessive snowfall in a narrow band near Omaha on 2 May in association with a strong, slow-moving front. Diagnosis of this has revealed a special set of circumstances related to radar bright-band issues that may require modification of our procedure for introduction of snow hydrometeors when high reflectivity exists near 0 deg C. The second snow-related issue was a distinct nighttime cold bias in 2-m temperature in areas of snow cover. This was tied to introduction of the MYNN planetary-boundary and surface layer, and is discussed under Task 3. This problem was fixed in early May.

On 6 April, the soil temperature and moisture adjustment in the RAPv2 stopped working when we added the capability to add a thin snow cover based on the IMS snow-cover analysis (we already trimmed snow cover under certain conditions using this analysis). Soil adjustment remained inactive until this problem was discovered by Stan and Ming Hu in mid-May and fixed on 17 May. During the time when the soil adjustment was inactive we noted that RAP forecasts in some areas were showing a progressively more serious moist bias in 2-m dew point, which led to the intensive effort that isolated the cause. Reinstatement of the soil adjustment gradually alleviated the high dew point bias over the next week or so. This dramatically illustrated the importance of the soil adjustment to our warm-season forecasts.

A modification was made to the GSI cloud/hydrometeor analysis to ensure clearing of all precipitating hydrometeors in model grid columns where there is at least partial radar coverage and these radar reflectivity observations indicate no precipitation, and in addition satellite observations give evidence that the model column is free of clouds. This change was prompted by discovery of false-alarm reflectivity areas for the 0h RAP analysis.

Currently, to save execution time, the variational part of the GSI in the RAPv2 code is run over a coarsened grid using every other grid point (same domain, 26km "2X" grid spacing). Ming Hu conducted 2 additional retro cycle tests to evaluate analysis and forecast fit to raobs (using both retrospective testing and the RAP-dev2 cycle on Zeus) when the full native 13km ("1X") horizontal grid is used. These tests have shown that 2x (4 times faster) and 1x versions give equivalent results.

Evaluation of the new GSI cloud analysis enhancements including Effective Cloud Amount (ECA) from the improved CLAVR-x (Clouds from AVHRR [Advanced Very High Resolution Radiometer] Extended) data from NESDIS continued during the early and late parts of the quarter. Although some reduction in RH moist bias in the 600-300 hPa range was achieved from these enhancements while building clouds at all levels from GOES data, we decided to hold off their implementation in the RAP primary and dev1 cycles until after the RAP freeze is over in November, to give opportunity for more parallel testing and evaluation of thresholds to use in determining areas of partial cloudiness (equivalent to METAR SCT or BKN sky cover). Now that MPEX is concluded, a new experiment using hybrid assimilation and CLAVR cloud data assimilation is underway.

Haidao Lin continued his work toward obtaining improved results for AIRS satellite radiance assimilation in the RAP. He made a presentation at the Joint Center for Satellite Data Assimilation workshop in May and is preparing a publication on this work under other funding.

Other activities, some noted more fully under other tasks, also were undertaken:

- The NCAR WRF developers officially released WRF version 3.5 on 18 April. This included a number of contributions by GSD developers: the latest version of the RUC LSM (Smirnova), the Grell-Freitas convection scheme, the MYNN PBL and surface-layer schemes (Olson) and the current version of the RAP digital filter initialization (Peckham and Smirnova). These physics upgrades (with the exception of the GF convection) are already in the v3.4.1 code being tested at NCEP for RAPv2.
- Retrospective testing for both RAP and HRRR of the impacts of proprietary in situ tower wind data and other special data continued under funding from the DOE Wind Forecast Improvement Project.
- Biweekly telecons between GSD and the Storm Prediction Center of NCEP continue to be very beneficial. The purpose of these telecons is to obtain feedback from SPC on RAP (RAPv2 from GSD as well as the operational v1) and GSD HRRR-primary performance, to give SPC opportunity to comment on our ongoing RAP and HRRR development work, and to inform SPC of planned Jet and Zeus computer downtimes.

NCEP

As of late June, a full parallel RAP V2 system has been set up and is running on WCOSS, and which is scheduled to replace the current version by the end of the CY (now delayed to Jan-Mar 2014). Production switches but more stability in

WCOSS firmware have repeatedly broken this cycle and hardware is expected next quarter. Work is also being done to start testing of the HRRR by assessing the WCOSS resource requirements as the initial step. (Geoff Manikin)

The transition of the RAP observation processing codes is complete. The NCO live data tests were completed in April. An improved method for maximizing the amount of LaRC GOES cloud data that goes into the RAP analysis was successfully tested, was submitted to NCO, and will hopefully be transitioned into the operational ingest in August after WCOSS 'go-live'. (Dennis Keyser)

A parallel RTMA system was set up this quarter to evaluate results from the method of using two separate analyses for land and lake 10-m winds, and the evaluation is underway. The goal is to improve the RTMA wind analysis over the major lakes. RAWS mesonet data dropouts and latency in the RTMA are being investigated. Although there have not been any major dropouts in the last few months and despite its being collected via the usually reliable GOES DCS, the arrival time of the data at NCEP is inconsistent and still of concern. Work continues to update the RTMA observation accept and reject lists, which are computed from the RTMA innovation statistics. (Manuel Pondeca, Steve Levine)

An alternative initialization in both land-surface states and atmospheric conditions was tested with the SREF system in April. Per a request by Jeff Tongue of the Eastern Region WFO in New York, the NARRE-TL was retrospectively run for an April 24 severe fog case at JFK Airport. This fog event was successfully predicted by NARRE-TL and the WFO made a case study of this event. (BinBin Zhou and Jun Du)

Work is complete extending NCEP's ensemble product generator from GRIB1 to GRIB2. Besides being mandatory (NCEP Central Operations is phasing out all use of GRIB1), this extension will greatly facilitate inclusion of more models into the future NARRRE, HRRRE and SREF ensemble systems. For example, outside ensemble runs from AFWA and / or CMC would be arriving at NCEP in GRIB2. In addition, many of the new fields being added to ensemble systems are not currently definable in GRIB1. This work, therefore, is foundational to moving forward. It is being tested on NARRE, SREF and the NSSE. (Binbin Zhou)

Bugs in the WCOSS level2-radar data decoder that prevented processing were found and fixed, so that dual-polarity data is decoded when the data volume is incomplete and raw level2 data is decoded when the data header is missing or radial beams at a single elevation are in nonconsecutive order. Another bug in the decoder for dual-pol variables was found during a parallel production test, and a fix is being developed.

A website to monitor reflectivity mosaic, no-qc reflectivity, dual-polarity variables and model forecast reflectivity (**http://www.emc.ncep.noaa.gov/mmb/wx22hl/REF/web/html/radar.html**) has been developed. Comparisons of radar data processing were done between the WCOSS machines Tide and Gyre, and changes were made to the Gyre processing to compensate for slower processing caused by the longer circuit path the radar data takes to Gyre. The radar-processing job was also modified to use an extra node on both Tide and Gyre to improve task performance and meet production deadlines. Current test results for a 2 month period from reflectivity assimilation in a real time NAM parallel show improvement; especially for precipitation scores. Tests were also done on assimilating reflectivity from GSD's cloud analysis package for Feb-June 2013. Precipitation scores for the first 24 hours of the forecast are improved and a slight improvement was found in the conventional data verification. Tests of GOES cloud data in NAM versus RAP prepbufr files were begun, and NAM prepbufr tends to include more data than the RAP prepbufr. The GSI was modified to use NASA LaRC cloud data. Comparisons of NASA versus NESDIS cloud data were made. The NAMREF parallel test system was completely transitioned to Zeus and testing has begun. Assistance was given to GSD in transitioning the RAP radar data pre-processing package to WCOSS. (Shun Liu)

CAPS

During this quarter, CAPS mainly worked on updating and testing the dual-resolution hybrid DA capabilities for RAP, using 40/13 dual resolutions. The main goal was to investigate why the dual-resolution results were not better than single 40-km-resolution results. All the experiments were rerun and forecasts were made up to 21 hours and verification was performed on the fly. Comparisons were made between the 40 km forecasts from 40 km GSI, EnKF and hybrid analyses and the 13 km forecasts started from the interpolated 40 km analyses, and it was found that the RMSEs of the 13 km forecasts are larger. The RMSE of 13 km forecasts started from 13 km GSI and dual-resolution hybrid were also larger than those from 40 km analyses.

To see whether the DFI setting differences used in the 40 and 13 km forecasts were the cause, we set the 13 km DFI window length to be the same as that of of 40 km forecasts of 40 min. The RMSEs of surface pressure of 13 km forecasts were deduced. For more fairly compare the RMSEs between 40 and 13 km forecasts, forecasts of 13 km were averaged

with 7*7 grid points before verification, and twice wider neighborhood for interpolation to the observation points in verification. With those settings, RMSEs for all variable verifications were deduced except for temperature against sounding.

Efforts were also spent on finalizing a journal paper summarizing the single-resolution hybrid results for submission.

Additional information on RAP-related tasks

ESRL

GSD continues to make pgrb and bgrb files from the ESRL/GSD RAP-primary (RAPv2) real-time 1-h cycle available from its FTP site for users in NWS and other labs).

NCEP

NCEP maintained real-time availability of SAV and AHP guidance to all vendors from the operational hourly RAP on pressure surfaces via the NWS Family of Services (FOS) data feed and via the FAA Bulk Weather Data Telecommunications Gateway (FBWDTG). (EMC&NCO)

NCEP maintained real-time availability of full resolution gridded data from the operational RAP runs via anonymous ftp access via the NCEP server site at **ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/rap/prod/** and at the NWS/OPS site at **ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/** in hourly directories named MT.rap_CY.00 through MT.rap_CY.23. This includes hourly BUFR soundings and output grids, which undergo no interpolation. Both sites now contain only grids in GRIB2 format **http://www.nco.ncep.noaa.gov/pmb/docs/GRIB1_to_GRIB2.shtml.** Gridded RAP and NARRE [-TL] fields are available on **NOMADS** for the CONUS domain on 13 km grid #130 and the Alaska domain on 11.25 km grid #242. RAP fields are also available for the larger North American domain on 32 km grid #221. A limited set of fields from the RAP runs (and other NCEP models) can also be viewed at A limited set of fields from the RAP runs (and other NCEP models) can also be viewed at **http://mag.ncep.noaa.gov** . (EMC&NCO)

Verification of RAP

ESRL's verification of the RAP is available from **http://ruc.noaa.gov/stats**. NCEP maintained its capability and provided access to routine verifications of the operational RAP analyses and forecasts. These include grid-to-station verifications versus rawinsonde, surface, aircraft, Profiler, and VAD data computed periodically at NCEP and accessible via NCEP's Mesoscale Modeling Branch website: **http://www.emc.ncep.noaa.gov/mmb/research/meso.verf.html** .

Deliverables	Delivery Schedule
Task 1 – Improve turbulence guidance from NWP forecasts	
a. Finalize code for RAPv2 for implementation at NCEP (ESRL, NCEP) • Vigorous effort leading complete package with extensive improvements, summary at: **http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2013.pdf**	Mar 2013 **COMPLETE**
b. Complete the testing of the 40/13 km dual-resolution hybrid DA system for RAP with 3-hourly cycles with conventional data (GSD, CAPS) • Initial work completed by CAPS, testing of further enhancements to system. GSD testing and inclusion in RAPv2 of hybrid system with full observational data, using GFS ensemble data. Milestones exceed.	Mar 2013 **COMPLETE**
d. Report on early version of RAPv3 primary cycle at GSD with physics enhancements for initialization of the HRRR. (ESRL)	Dec 2013
e. Report on the optimal configurations for including satellite data in the 40/13 km dual-resolution hybrid system to ensure overall positive impacts of the data	Dec 2013

Deliverables	Delivery Schedule
(NCEP, ESRL)	
f. Finalize RAP version to initialize experimental HRRR for 2014 real-time use toward operational HRRR (ESRL)	Mar 2014
g. Deliver progress report on development of NARRE (NCEP, ESRL)	Mar 2014
h. Deliver progress report on ensemble/hybrid data assimilation for use in NARRE (ESRL, NCEP)	Mar 2014
i. Subject to NCEP Directors' approval, upgrades to observation processing &/or quality control and/or GSI and/or NMMB systems become Operational at NCEP. (NCEP)	Mar 2014
j. Incorporate physics and dynamics improvements from the user community, GSD, and NCEP into WRF for use in the Rapid Refresh system. (NCAR-MMM)	Mar 2014

Task 2: Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

GSD

During the quarter, GSD personnel were active in evaluating the updated and frozen 2013 version of the HRRR system. Overall results indicate that the new enhancements are yielding very good results. Especially notable is the skill improvement in the 0 – 4 hour forecast time frame that results from the new 3-km radar assimilation during the HRRR pre-forecast hour followed by the 3-km application of the GSI 3DVAR (for conventional observations) and cloud analysis. Other factors, including the enhancements to the parent RAP (especially the new PBL and improved soil scheme) are also key factors. As part of our monitoring, we are seeing very good quantitative scores and also many cases of very good forecasts in our subjective evaluation. We have also received a number of complements from National Weather Service forecasters on very good (and helpful) HRRR forecasts for challenging forecasts cases.

Also during the quarter, joint work by AMB and EMC personnel was initiated and completed to build and test the April 2013 version of the HRRR (including the new 3-km pre-forecast hour with the radar assimilation and 3DVAR and cloud analysis). A major purpose of this test is to determine WCOSS resource requirements for the HRRR with the full 3-km data assimilation. Recent work by EMC computer specialists has led to a significant reduction in runtime for the HRRR system to 45min on WCOSS using the existing planned node assignment. This is very good news. The HRRR is currently slated for NCEP operational implementation in Q3 FY14 (April – June 2014), which includes a quarter delay due the increased in time needed for the NCEP switchover to the WCOSS machine.

Recent work within AMB has focused on preparation for a major combined RAP/HRRR retrospective test run for the extremely convectively active period in May 2013. Much of the work so far has been completed by Eric James and has included staging all the needed data from the mass store and checking all the scripts for completing the runs. Because of the soil moisture updating problem in the real-time RAP/HRRR during late April / early May time frame, the late May retrospective period will be proceeded by a 2 week soil spin-up period. In addition to further evaluating a variety of RAP / HRRR aspects (model and data assimilation) for this very challenging period, new capabilities will be evaluated. Key among these new capabilities is 3-km radar radial velocity assimilation procedure.

During the period, three AMB personnel (John Brown, Eric James, and Curtis Alexander) traveled to Norman, OK and participated in the SPC spring program. During the week that each person spent there, they intensively analyzed high-resolution output from many models and gained good insight into HRRR performance characteristics. Fig. 1 below, shows a sample forecasts from the May 31, 2013 El Reno tornado that cause several fatalities west of Oklahoma City. As part of his visit to SPC, Curtis Alexander presented a seminar on the HRRR and related RAP improvements.

31 May 2013 Oklahoma/Missouri tornado/flashflood event

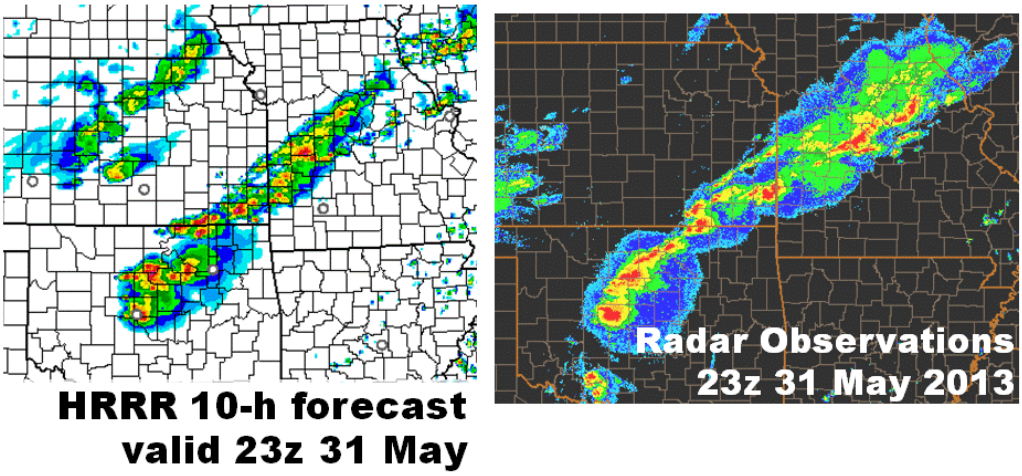

Fig. 1 (left) HRRR +10h forecast reflectivity valid 23z 31 May 2013. (Right) 23z 31 May 2013 radar observed reflectivity.

Patrick Hofmann continued his work on the RTMA, by getting it running again in real-time on GSD computers. He is also working with Tracy Smith to convert GSD 15-min observation files (METAR, mesonet, etc.) to the GSI required prepBUFR format on a 15-min real-time basis. He is making good progress on this task to get a 15-min version of the HRRR-based RTMA running in near-real time, however, we request a delay until the end of August 2013. Remaining work on this includes completing the 15-min observation ingest code and finalizing the scripts,

NCEP

NCEP EMC and NCO conducted a planning exercise of what the modeling suite might look like on the Weather and Climate Operational Supercomputing System (WCOSS) Phase 1 (2013-2015) and Phase 2 (2015-2018). The size of the latter would be enhanced by the Sandy Supplemental funds. This plan incorporated ESRL/GSD along with all other contributors to the NCEP Production suite. NWS Director Louis Uccellini was briefed 28 March. While tentative, these plans called for HRRR implementation on Phase 1 and a HRRR Ensemble (HRRRE), combining multiple runs with configurations of both WRF-ARW and NMMB, on Phase 2. A sizable bank of computing was dedicated on Phase 2 to advanced data assimilation for the convective allowing scales of the HRRRE, likely involving a 4-dimensional version of the current GSI-hybrid-EnKF.

NCEP & ESRL

The computing resources on NOAA R&D machine Zeus are being used by ESRL/GSD to run HRRR which together with the primary run on Jet comprise a 98.3% reliable source for HRRR. The Weather and Climate Operational Supercomputing System (WCOSS) are replacing NCEP Central Computing System. WCOSS Phase 1 resources amounting to 65 nodes for the entire 24-hour period have been allocated to HRRR. Scheduling of the HRRR implementation is difficult due to the current issues on WCOSS that have impacted development there. The 'go-live' date has slipped by a week to 23 July 2013. It is known that RAPv2 needs to be implemented before HRRR so current emphasis is on a RAPv2 real-time parallel on the development side of WCOSS. A very tentative schedule currently has RAPv2 being implemented in Q1FY2014 (Oct-Nov-Dec) with HRRR being implemented in Q2FY2014 (Jan-Feb-Mar), but

these dates have not been confirmed by NCEP Central Operations so they should not be relied upon on nor communicated widely.

Deliverables	Delivery Schedule
Task 2 – Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE	
a. Report on initial tests of 3-km 15-min RTMA cloud / surface analysis for use in frontal diagnostics, CI assessment and other near-surface assessments (ESRL, NCEP) • *Good progress toward 3km RTMA and RUA surface and cloud analyses* • *Successful initial tests summarized in report:* **http://ruc.noaa.gov/pdf/GSD_RTMA_report.pdf**	Feb 2013 COMPLETE
b. Incorporate all assimilation and model changes that affect the HRRR into a frozen version of HRRR (and parent Rapid Refresh) for 2013 real-time use (ESRL) • *Extensive set of enhancements in place and running in real-time experimental GSD RAPv2 / HRRR system*	Mar 2013 **COMPLETE**
c. Provide preliminary 15-min RTMA surface analyses as experimental improved basis for frontal diagnostics and other diagnostics from surface analyses (ESRL, NCEP) **Real-time hourly RTMA restored and showing good results. Work ongoing to automate real-time 15-min. processing of observation files.**	Apr 2013 **Request delay to August, 2013**
d. Report on computing resource status on NCEP Central Computing System, NOAA R&D Site A and NOAA R&D Site B with regards to possible implementation of HRRR (NCEP, ESRL) HRRR now planned for NCEP operational implementation in Q3 FY14 (April – June 2013)	**June 2013** **COMPLETE**
e. Complete FY13 internal assessment with revised 3-km HRRR running every hour (ESRL)	Sept 2013
f. Provide revised 15-min RTMA surface analyses as primary basis for frontal diagnostics and other diagnostics from surface analyses for real-time use in 2014 (ESRL, NCEP)	Feb 2014
g. Finalize all changes to the HRRR for real-time use in 2014 (ESRL)	Mar 2014

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GSD

To summarize from the FY2013Q2 report, extensive testing and evaluation of physics options for RAPv2 continuing through January and February into March led to the late March decision on the following physics configuration for RAPv2 used within the WRFv3.4.1 code:

- New 9-level configuration of the RUC land-surface model (RUC LSM)

- Mellor-Yamada-Nakanishi-Niino (MYNN) planetary-boundary- and surface-layer scheme in place of the current Mellor-Yamada-Janjic (MYJ) scheme.
- Continue use of the Grell G3 scheme from WRFv3.2.1.
- Continue use the Goddard short wave and RRTM long-wave radiation schemes.
- Use WRFv3.4.1 version of the Thompson microphysics.

As noted under Task 1, a notable cold bias showed up over areas of snow cover during April and early May. Investigation of this unexpected problem by Joe Olson and Tanya Smirnova led to the discovery that code that uses a special formulation for the roughness length for heat over snow cover (Andreas 2002, *J. Hydromet.*) introduced late last year had been inadvertently deactivated in late March. As a result, the coupling between the cold snow surface and the adjacent atmosphere was too large, resulting in the cold bias. The use of the Andreas formulation was restored in early May.

Also as noted under Task 1, a low-level daytime moist bias showed up in the RAP primary cycle at GSD during May. Because in our parallel and retrospective testing with the MYNN PBL and surface layer scheme against the MYJ, the MYNN produced slightly drier conditions, this was not anticipated. As noted under Task 1, very recently we made a modification of our partial cycling that should reduce possible contamination from a too-moist GFS. However, what proved to be the main problem was that the soil temperature and moisture adjustment (which is based on certain criteria applied to the 2-m METAR observation innovations) had inadvertently been disabled in April

During May we initiated what we intend to be regular telecons with the land-surface group at NCEP headed by Mike Ek (second held in June). The purpose of this exchange is to learn more about available land-surface datasets and other ongoing work in the land-surface modeling arena, both on the regional and global scales.

Joe Olson continues to experiment with further improvements to the MYNN planetary-boundary and surface-layer schemes. Both he and Tanya Smirnova, respectively, have had much correspondence with users in the worldwide WRF user community concerning the WRFv3.5 versions of the MYNN and the new 9-level version of the RUC LSM. The same is true for Georg Grell and the Grell-Freitas scheme.

Test and evaluation of the Grell-Freitas convective parameterization was temporarily suspended in mid-May to accommodate data impact comparisons for the MPEX project (See Task 1). Georg Grell continues to analyze issues with the G-F scheme uncovered in RAP testing and we are not excluding its use in later versions of RAP. He and Saul Freitas have prepared a manuscript for submission to a prominent journal describing this scheme.

The use of WRFv3.4.1 by default incorporates the NCAR (Greg Thompson) fix to allow attenuation of incoming solar radiation by clouds in the Goddard short-wave radiation scheme. So this is part of the RAP physics configuration used with the RAP-primary that feeds the HRRR for this summer's convection exercise.

GSD requests deferral of Deliverable 3.c (Request for Change for RAPv2 physics) from May to Sept 2013.
As described earlier under Task 1 efforts, testing is now underway for RAPv2 on the new NCEP WCOSS computer. But this date was inadvertently set too early.

NCEP

NCEP/EMC hosted a visit by Greg Thompson of NCAR/RAL from 20-23 May, during which he gave a seminar (20th) and interacted with modelers in the Mesoscale Modeling Branch, the Global Modeling Branch, and the Hurricane Group. Success was achieved in the goal of integrating his cloud microphysics into the NOAA Environmental Modeling System (NEMS) Nonhydrostatic Multiscale Model on B-grid (NMMB), and establishing a template for coupling his microphysics with the Rapid Radiation Transfer Model (RRTM) radiation package within NEMS. This achievement will allow additional collaborations in the future during which the sensitivity of forecast guidance quality to various cloud microphysics treatments will be examined. (Brad Ferrier)

NCAR/RAL

CURRENT EFFORTS: During the month of June, NCAR-RAL continued to analyze a suite of three-dimensional sensitivity experiments of a 72-hour storm period began writing a journal article regarding the results using the "aerosol-aware" Thompson et al microphysics scheme. A portion of the analyses was also prepared and presented on a poster at the annual WRF Users Workshop.

FUTURE EFFORTS: NCAR-RAL will work closely with colleagues at NOAA-GSD to transfer and guide code integration, especially more explicit coupling with their existing WRF-Chem model configuration.

PROBLEMS/ISSUES ENCOUNTERED: Funding for a part of 2013 ran out while various steps to continue funding via AWRP to NSF to NCAR continues to work through the system. But, activity on this project suffers from many start-stop cycles due to this problem.

INTERFACE WITH OTHER ORGANIZATIONS:
Alison Nugent (PhD student) and Ron Smith, Yale University
Yaitza Luna (PhD student), Howard University
Antonio Parodi, CIMA foundation, Italy

NCAR/MMM

Deliver a WRF Users' Workshop and WRF Tutorial for the User Community

NCAR organized and delivered the 14th WRF Users' Workshop (**http://www.mmm.ucar.edu/events/2013_wrfusers/index.php**). This given at NCAR's Center Green facility in Boulder on June 24–28, and the attendance was 220. The program opened with lectures on model radiation schemes and effects of clouds, ozone, and aerosols. The following three days featured WRF-related presentations and discussions, with plenary sessions, modeling area discussion groups, and a poster session. The final day offered tutorial-type sessions on topics such as WRF-Hydro, NCL, VAPOR, and model verification.

NCAR also prepared for the next WRF tutorial at its Foothills Lab, which will be July 15–26, 2013. This will include a basic WRF tutorial, a WRFDA tutorial, a WRF-Chem tutorial, and a WRF regional climate tutorial. The tutorial is described at: http://www.mmm.ucar.edu/events/tutorial_137/index.php.

PLANNED EFFORTS: NCAR will gather participant feedback on the users' workshop and use that in the planning for next year's event. NCAR will also host and conduct the next WRF tutorial in July.

UPDATES TO SCHEDULE: NONE

Incorporate Physics and Dynamics Improvements into WRF

In this quarter NCAR issued WRF major release Version 3.5, and details are at: **http://www.wrf-model.org/release.php**. Version 3.5 includes software framework improvements, a new WRF hydrology model, new physics options, new observation types for WRFDA, and WRF-Chem additions.
Jimy Dudhia of NCAR/MMM contributed significantly to the preparations for WRF V3.5 release.

Dudhia coordinated work on shallow convection and cloud-radiation-aerosol effects. The new shallow cumulus parameterization is the Deng scheme being developed at Penn State. In WRF microphysics, Greg Thompson (NCAR/RAL) has been modifying the Thompson scheme to pass hydrometeor information to radiation packages for closer interaction of radiation and microphysics. NCAR/MMM visitor Jose Ruiz-Arias (University of Jaen) worked on a new parameterization for WRF to provide information on clear-sky aerosol effects to the RRTMG and Goddard radiation schemes.

Dudhia worked with Pedro Jimenez (CIEMAT, Spain) and Raquel Lorente (Univ. of Murcia, Spain) on evaluating diurnal errors in WRF surface wind simulations and modifying the model's "topo_wind" parameterization finding improvements in the topo_wind parameterization. They found that the topo_wind scheme underpredicts winds in day-time conditions, and they have made progress in improving it by reducing or removing the topo_wind effect for convective PBL situations.

Dudhia started collaborating with NCAR visitor Esa-Matti Tastula (Univ. of South Florida) on evaluating the QNSE-EDMF PBL scheme in single-column and real-data tests. While this scheme has shown a problem of too-little daytime mixing in 1-D tests, they have resolved problems in running with specified flux conditions. They also implemented a fractional sea-ice option for this scheme.

Dudhia continued working with Jose Ruiz-Arias (Univ. of Jaen) on improving the solar radiation computational methods. Ruiz-Arias has made SWDOWN change more gradually without having to call the solar radiation more frequently, by using the timestep sun-angle computation. The goal is to reduce the step effect of the radiation call frequency.

Dudhia continued collaborating with Stephanie Evan (NOAA/ESRL) on WRF simulations of the tropical tropopause layer (TTL). They made modifications to the WSM5 scheme to improve the TTL cold-point water vapor.

Recently Dudhia added a number of minor code changes to the WRF repository. The first was a fix for the YSU PBL scheme for instability (seen in the context of MPAS) related to excessive in-cloud mixing. The second was a modification of the Garratt formulation of thermal roughness length that explicitly represents constants for readability (from Ben Green, Penn State). The third was improved logic for computing the PBL regime needed by FDDA and dependent on the surface-layer option chosen (tested by Penn State). The fourth was the implementation of limits in the WSM6 and WDM6 microphysics schemes to avoid problems of log(0). Dudhia and Wei Wang (NCAR/MMM) also corrected a problem involving jumps in WRF time-series 2m dewpoint temperature, and the fix was put into the repository.

PLANNED EFFORTS: The development and incorporation of new physics and dynamics for WRF for the RAP will continue through FY13Q4.

UPDATES TO SCHEDULE: NONE

Deliverables	**Delivery Schedule**
Task 3 – Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE	**Delivery Schedule**
a. Complete initial evaluation of aerosol-aware microphysics in RAP real-time cycling at GSD for its suitability as part of the RAPv3 prototype for 2014 NCEP implementation (NCAR-RAL, ESRL)	Delay until funding restored to NCAR
b. Final model physics code transfer complete to EMC for Rapid Refresh 2 upgrade change package to be implemented at NCEP by spring 2014 (ESRL, NCEP) • Freeze of model physics code for March 2013 version of RAP at ESRL allows this milestone to be met.	Mar 2013 **COMPLETE**
c. Pending NCEP computer readiness and EMC and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit WRF physics code changes as part of upgrade for Rapid Refresh v2 software to NCO (NCEP, ESRL)	May 2013 **Request defer to Sept 2013**
d. Transfer upgraded coupled aerosol-microphysics scheme into a test version of HRRR (NCAR-MMM, ESRL)	Dec 2013
f. Finalize microphysics changes and other physics changes to improve icing forecasts for ESRL version of RAP and HRRR for 2014 real-time use (ESRL)	Mar 2014
g. Report summary of icing probability skill measures by quarter for the year. (NCEP)	Mar 2014

Task 4: Develop convection-ATM-specific improvements for guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA

Task 4 – Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2013 real-time use (ESRL)

Current:
Following extensive retrospective testing, the new Thompson microphysics scheme from WRF-ARW version 3.4.1 was installed in the ESRL RAP and HRRR prior to the code freeze on 10 April 2013 and the start of the CoSPA season on 17 April 2013.

Ming Hu, David Dowell and Tanya Smirnova developed an improved retrieval in GSI of rain and snow hydrometeors from radar reflectivity observations that resulted in a reversible diagnostic of model reflectivity in WRF from the hydrometeors that both matches the observed reflectivity and is consistent with the model microphysics scheme (Thompson) used in the RAP and HRRR. This work has led to an improved analysis of radar reflectivity, including echo tops, and these initial conditions translated into improved reflectivity and echo top forecasts from the RAP and HRRR as reported in the previous quarter.

Additional retrospective testing is underway to improve the retrieval of rain and snow from reflectivity observations in mixed-phase regions including a reduction in the maximum retrieved snow mixing ratio in regions of higher observed reflectivity's due to potential bright-banding. To account for ambiguities of precipitation type from radar reflectivity observations, a balanced hydrometeor retrieval is also being tested whereby retrieved snow mixing ratios from radar observations include corresponding reductions in model rain and graupel mixing ratios to avoid excessive precipitation loading and a high bias model reflectivity and VIL values.

A new retrospective period from 15-31 May 2013 has been established to begin evaluation of model and data assimilation changes for the 2014 version of the ESRL RAP and HRRR.

Planned:
An evaluation of the latest Thompson microphysics scheme in WRF-ARW version 3.5.1 will be conducted including testing and calibration of the associated reflectivity, VIL and echo top diagnostics.

Task 4 – Assess HRRR reliability and provide monthly reporting (ESRL)

HRRR Reliability for 0-8 Hour VIL/Echo Tops for April 2013
Note: statistics are lower for April because during the early part of April, Jet and especially Zeus were used extensively for final RAPv2/HRRR testing and code finalization for the code freeze. Reliability has been considerably higher since the codes freeze.

Jet
All runs: 68.8%
3 or more consecutive missed runs: 84.9% (most meaningful for CoSPA)
6 or more consecutive missed runs: 93.3%
25 outages of at least 3 hrs. or longer
13 outages of at least 6 hrs. or longer

Zeus
All runs: 34.9%
3 or more consecutive missed runs: 48.1% (most meaningful for CoSPA)
6 or more consecutive missed runs: 58.5%
32 outages of at least 3 hrs. or longer
13 outages of at least 6 hrs. or longer

Combined (Jet or Zeus)
All runs: 76.1%
3 or more consecutive missed runs: 88.5% (most meaningful for CoSPA)
21 outages of at least 3 hrs. or longer

HRRR Reliability for 0-8 Hour VIL/Echo Tops for June 2013

Jet
All runs: 95.6%
3 or more consecutive missed runs: 97.1% (most meaningful for CoSPA)
6 or more consecutive missed runs: 98.2%
3 outages of at least 3 hrs. or longer
2 outages of at least 6 hrs. or longer

Zeus
All runs: 74.0%
3 or more consecutive missed runs: 79.9% (most meaningful for CoSPA)
6 or more consecutive missed runs: 82.1%
6 outages of at least 3 hrs. or longer
4 outages of at least 6 hrs. or longer

Combined (Jet or Zeus)
All runs: 97.4%
3 or more consecutive missed runs: 97.9% (most meaningful for CoSPA)
6 or more consecutive missed runs: 98.3%
1 outage of at least 3 hrs. or longer
1 outage of at least 6 hrs. or longer

Task 4 – Complete implementation of refined SatCast assimilation for HRRR for real-time use in 2014

Tracy Smith ported SatCast assimilation code (previously developed for use with the RUC analysis) from the RUC to the RAP (GSI package). The code ingests SatCast IR cloud-top cooling data and maps it into a local heating function that is applied to the RAP fields in a similar manner to the way the RAP assimilates radar reflectivity data. Using a sample IR cloud-top cooling rate data set from a convectively active period in early July 2012, she completed a preliminary 1-day retrospective experiment (control run without the SatCast data and experiment with the SatCast data). Preliminary results indicate that for a scattered thunderstorm situation over the Southeastern U.S., assimilation of the SatCast IR cooling rates leads to a better short-term prediction of small-scale convective systems. Further work is ongoing.

Task 4 – Interact with CoSPA (or other) program partner labs and the FAA

Team (ESRL/GSD, NCAR/RAL, and MIT/LL) telecons and e-mail correspondence have and will continue to occur to discuss issues related to the HRRR reliability including scheduled outage periods during the CoSPA 2013 season.

Deliverables	**Delivery Schedule**
Task 4 – Develop convection-ATM-specific improvements to guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA	
Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2013 real-time use (ESRL) • Code for revised echo-top / reflectivity diagnostics with revised microphysics implemented in GSD real-time HRRR.	Mar 2013 **COMPLETE**
Conduct baseline testing of the early 2013 HRRR version (ESRL) • Baseline testing of 2013 HRRR version completed as part of code	Mar 2013 **COMPLETE**

preparation for freeze. Summary of skill score improvements being prepared.	
Report on evaluation of new microphysics scheme and associated echo-top and reflectivity diagnostics in ESRL/GSD RAP and HRRR (ESRL) • *Preliminary evaluation completed and summarized in report:* **http://ruc.noaa.gov/pdf/GSD_reflectivity_report.pdf**	Mar 2013 **COMPLETE**
Assess HRRR reliability and provide monthly reporting (ESRL) Reliability statistics are being reported each month	*Apr 2013* **COMPLETE** *(ongoing)*
Report on evaluation of revised WRFv3.4 microphysics for RAP/HRRR for its effects on echo-top and reflectivity in ESRL RAP/HRRR (ESRL)	Mar 2014
Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2014 real-time use of HRRR (ESRL)	Mar 2014
Complete implementation of refined SatCast assimilation for HRRR for real-time use in 2014 (ESRL)	Mar 2014
Report on 2014 baseline testing of the HRRR (ESRL)	Mar 2014